CATALOG 365

-2 SERIES CARDS

SPACE CRAFT, INC./8620 S. MEMORIAL PARKWAY/HUNTSVILLE, ALA.

PHONE 881-1611 / AREA CODE 205

-2 SERIES LOGIC CARDS

When special, custom-built digital systems are to be designed, built, debugged, and installed, maximum profit can be realized if expensive engineering labor can be held to a minimum. Space Craft's -2 Series logic cards have been designed to minimize engineering time by making them easy and convenient for the system designer to use. There are a minimum number of card types, operating rules are simple and straightforward, and specifications are conservative.

But that's just the beginning! There are several more reasons why Space Craft's "building block" logic approach can save you time, toil, trouble, - - - and money. Read on. We think you'll be interested.

TIME SAVINGS

When you design a system with SCI modules, you can eliminate unpredictable time requirements for circuit development, testing, correcting and retesting - - - requirements which stretch out your system development schedule. Such time savings represent substantial savings in total system cost.

COST CONTROL

Estimates and cost control are simplified by using SCI's prepriced building blocks. This eliminates a major unpredictable factor from the time cost race, even in production of a single prototype.

CUSTOMER PROTECTION

Your customer is protected in case the system you install requires subsequent circuit replacements or modifications. Off the shelf deliveries can supply the modules and you need not bother with special production of a few circuit types. It also pays to have SCI's warranty backing every circuit module in the systems that bear your company insignia.

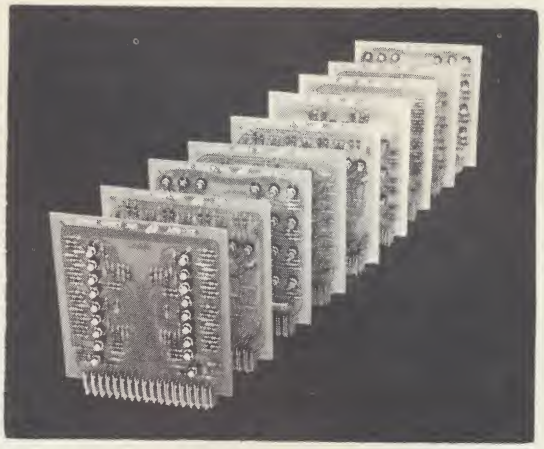
MAXIMUM VERSATILITY

If the family of logic is to have maximum versatility, then why is the number of circuit types held to a minimum? There are three reasons why. First, the fewer elements in the family, the easier it is for the system designer to remember all elements in that family. On the other hand, the family must be complete enough to implement most system problems. To achieve this, we have analyzed the circuit mix in a large number of digital systems to determine which circuits and combinations of circuits offer the most economical solution to system problems.

Second, We then determined the maximum number of circuits (in each type category) that could be economically packaged on a logic card of dimensions that were convenient for handling **and** that were compatible with commercially available card files.

Finally, in the "english" logic versus NOR/NAND logic decision, we decided in favor of NOR/NAND logic because of inherent advantages from the standpoint of flexibility, level restoration, and standardized loading. These features greatly reduce the adjustment and reworking time so often required between a logic diagram and the final, correctly operating system. For example, when circuits are added to or subtracted from a developing system, it isn't necessary to rework adjoining sections to bring the whole back into balance.

What does all of this do for you? It means that each circuit type is designed for a wide variety of applications. You have more capability per card and you purchase fewer different card types thus simplifying stocking and spare problems. Further, with fewer card types, you can more readily achieve quantity discounts further reducing card costs. On top of this, with the circuit density provided, **total system costs** are reduced because system wiring is minimized and systems are more compact. Moreover, if SCI's standard circuits do not match your particular system requirements as closely as you like, Space Craft is prepared to assemble combinations of circuits on a card or even design, as a special circuit, cards that do exactly meet your requirements.



APPLICATION ASSISTANCE

SCI modules are subject to very diverse applications. Our extensive and constantly accumulating applications experience enables Space Craft engineers to offer technical assistance regarding effective and economical use of digital modules and logic cards.

LOAN OF CIRCUITS

We are prepared to loan you, without obligation, a reasonable quantity of SCI logic cards for a 30-day evaluation period.

In order to obtain merchandise on a 30-day loan, send us a purchase order for the required units with a notation on the purchase order that the units are being shipped on a 30-day loan basis. The merchandise will be shipped to you with our regular invoice; terms are net 30 days from date of invoice. When you return the material, please return one copy of our invoice with the material and your account will be credited. You will be charged **only** for repair of damage to units that may be caused by misuse, neglect, accident, or improper installation or application.

SPECIAL CIRCUIT DEVELOPMENT

SCI is well equipped to handle custom circuit work required for certain type systems. The most advanced packaging techniques are always available and our production of your custom modules can eliminate any concern you might otherwise have about future replacements of one or two modules in a system.

We invite requests to produce special units tailored to your specific needs. Because of our experience in package design and assembly methods, we can produce these specials at a cost favorably comparable to the cost of an equal number of standard items. Prices on your special circuits can be estimated within 20 to 25 percent by comparing your circuits with similar circuits in SCI data sheets. When quotations are requested, or when orders are placed on an "advise price" basis, the following information is required:

(1) circuit schematics

(2) Bills of materials with transistor and diode types, resistor values tolerances and wattages, and capacitor values, tolerances, voltages, and (where necessary) temperature coefficient.

FAMILY INFORMATION

Space Craft's -2 Series of standard logic cards form a family of transistor digital circuits intended for compact ground systems and equipment. Featured in the -2 Series are:

(1) minimum number of circuits in the family
(2) maximum circuit density on the cards
(3) low cost
(4) operating speeds up to 1 Mc
(5) NAND/NOR active logic (positive logic)
(6) simple loading rules and complete family compatability
(7) conservative specifications
(8) keyed cards for error-free insertion

"Varicon" 35-pin connectors were selected as the board interconnection medium in order to avoid pin-connection limitations because the maximum number of circuits, commensurate with good design practice was put on each card. In determining which circuits to use and which quantities to put on each card, Space Craft has analyzed the "circuit mix" in a large number of digital systems to determine which circuits and combinations of circuits offer the most economical solution to most system problems. Reference to the individual card specifications will reveal the answer that we came up with.

As implied in the preceding paragraph, reduction of **total** system costs has been a major consideration in the development of this family of logic cards. This means more than just reduced circuit prices (although we welcome comparison of our prices with any other comparable lines). Space Craft has also considered system hardware and wiring costs, hardware costs from the standpoint of compactness achieved by high circuit density and physical compatibility with commercially available card mounting hardware, and wiring costs from the standpoint of, again, reduced size **and** standardized pin connections. For example, power connection pin assignments are uniform in order to allow buss wiring.

Our experience with and study of digital systems has revealed that an overwhelming percentage of applications exist at frequencies below 1 Mc. Hence, this family was designed for operations at frequencies up to 1 Mc.

NAND/NOR active logic was selected for the reasons listed in the paragraphs to follow (under "Design Philosophy"). The combination of restored logic levels and simple standardized loading that is realized greatly reduces any adjustment and reworking time that may be required as modifications are made to the logic diagram during development of a system. When -2 Series circuits are added to or subtracted from a developing system, it is not necessary to rework adjoining sections to compensate for loading changes. Further, simple and easy-to-remember loading rules result with the added benefit that any clamped diode-transistor circuit can drive,and be driven by, any other clamped diode-transistor circuit.

Circuit specifications are conservative. Each circuit design is based on derated specifications for the **proven** components used. Moreover, the resulting circuit specifications are then further derated to give reserve reliability.

All logic cards are supplied with coded key slots, thus providing means for a mechanical interlock. Keying tabs can be placed on chassis connectors to correspond to key slots in the -2 Series cards thereby insuring against accidental insertion of an incorrect card type.

CONTENTS

DESIGN PHILOSOPHY

Designed from worst-case considerations, Space Craft's -2 Series logic cards feature medium speed (1 Mc) operation, low cost, and high reliability. A key design objective was to keep the number of different elements to a minimum without sacrificing versatility. This provides a set of logic elements that is easy to design with and, yet, minimizes "spares" and stocking problems. Further, with fewer card types, quantity discounts are readily achieved, further reducing costs.

Another design objective for this family was card density. With more circuits per card, **total system costs** are reduced because system wiring is minimized and systems are more compact.

A third important feature of Space Craft's -2 Series of standard logic cards is that any clamped diode-transistor circuit can drive or be driven by any other clamped diode-transistor circuit. (Only two circuits are in- active, the Diode Logic Extender cards, and these are intended to be used only to increase fan-in of NOR and NAND gates.)

No circuits require special drivers.

Saturated, diode-transistor NAND and NOR circuitry comprise the basic logic elements in the family. (Both NAND and NOR circuits are offered in order to minimize hardware.) DTL logic has been selected over other configurations (such as RTL, DCTL, non-clamped, etc.) because it offers the best compromise to achieve moderately high speed, low cost, high fan-in capability, moderate fan-out capability, and clamped, low impedance output in both logic "1" and logic "0" states. These same advantages are achieved in the memory elements of the family which are versions of Eccles-Jordan type circuits.

GENERAL SPECIFICATIONS

A positive logic convention is used in Space Craft's -2 Series of logic cards. Nominal logic levels are 0 VDC (binary "1") and -6VDC (binary "0") and flip-flops are triggered by the voltage change from binary "0" to binary "1". All circuits reject input noise at amplitudes up to 1.5 volts peak-to-peak.

Supply voltages required are -6VDC (±2%), +6VDC (±5%), and -15VDC (±5%). Lambda Electronics Corp. type LH supplies are recommended. For applications involving up to 75 cards, two quarter-rack (LH-121) and one half-rack (LH-122) supplies are more than adequate.

The cards are 1/16-inch thick G-10 fiberglass with 2 oz. copper wiring. They are dip soldered and then given an acryloid coating to provide a fungus and moisture-resistant protective coating. Card dimensions are 5.05 (±0.02) inches long by 4.50 (±0.02) inches wide. Connections to rack or drawer wiring are made through 35-pin Elco "Varicon" connectors and the same pins are used on all boards for supply voltages to allow "bussing" of power connections. Pin assignments are as follows:

Pin 1: +6VDC
Pin 3: —6VDC
Pin 33: Ground
Pin 35: —15VDC

LOADING INFORMATION

As mentioned earlier, loading rules are simple because of the fact that active logic is used and any circuit can drive any other circuit. For specification purposes, circuit loading is standardized in terms of P units and N units, and AC units. Input impedance specifications as well as load-drive-capability specifications are presented in terms of these units. The load units are defined as follows:

one P unit = 4.7 kilohms resistance to ground
one N unit = 6.8 kilohms resistance to —15VDC
one AC unit = 47 pf shunted by 1N plus 1P load units.

A load chart for the —2 Series logic cards is as follows:

Circuit	Load Presented	Drive Capabilities (any combination up to:)
NOR-2	1N unit	3N and 3P units*
NAND-2	1P unit	3N and 3P units*
UFF-2	Gate Input: one AC unit Pulse Input: one AC unit	3N and 3P units in addition to 3 AC units
SFF-2	Gate Input: one AC unit Pulse Input: one AC unit Toggle and Shift Inputs: two AC units each	3N and 3P units in addition to 3AC units
OS-2	Gate Input: one AC unit Pulse Input: one AC unit	2N and 2P units*
MV-2	Sync Input: one AC unit	20N and 35P units*
CD-2	1P unit	20N and 35P units*
ADD-2	NAND Input: 1P unit Half-Adder Input: 1N and 1P unit	Sum, Carry, and NAND Outputs: 3N and 3P units* $\overline{\text{Carry}}$ Output: 1P unit*
ULC-2	10K ohms (see data sheet)	3N and 3P units*
RD-2	1N unit	up to 120 ma @ up to —52V
ND-2	1/8N and 1/2P unit	Burroughs type B5991 Nixie tube

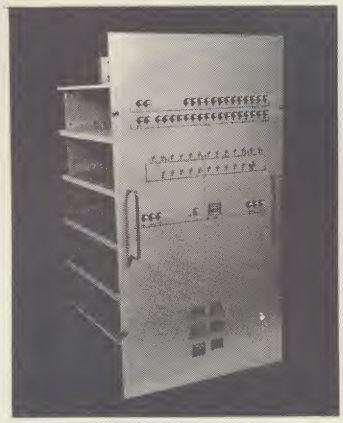
* For these circuits, an AC load unit is equivalent to 1N plus 1P load unit.

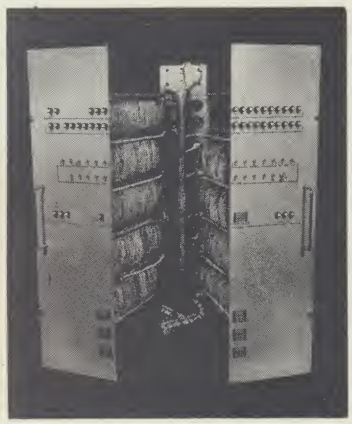
ACCESSORIES

As a service, Space Craft, Inc. also offers three types of card drawers, a large card file, and a card extractor.

CARD FILE

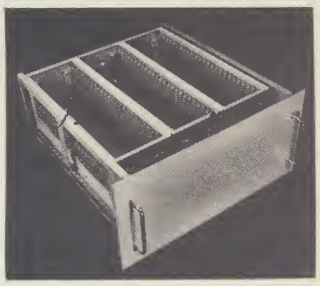
The Card File accommodates up to 270 cards. It is a split-type mounting case that fits into a standard 19-inch rack. The file pulls out of the rack and opens like a book, as shown in the photograph, to provide easy access to the cards, card connectors, and cabling. The front panels are 35 inches high and depth behind panel is 20 inches. Handles, panduit wiring channels, card guides, and slides (4) are supplied with the file. Connectors are not supplied.

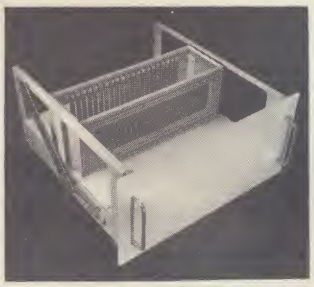




CARD DRAWERS

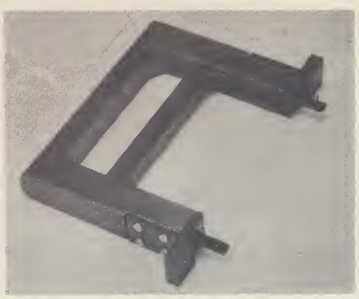
The Card Drawers accommodate 25, 50, and 75 cards respectively. Photographs of the 25-card drawer and the 75-card drawer are shown. Front panels are 8¾ inches high, depth behind panel is 18 inches, and panel width is a standard 19 inches. Tilt-type slides, handles, panduit wiring channels and card guides are supplied. Card connectors and back-panel connectors are omitted so that the customer can install what exactly meets his requirements.





CARD EXTRACTOR

The Card Extractor engages the circuit card through corner holes. Feet on the extractor seat firmly on the "bucket" rails and a squeeze of the handle causes smooth, straight-line withdrawal of the card from the bucket or file.



CONVERTING ENGLISH LOGIC TO NAND - NOR LOGIC

Space Craft's —2 Series Logic operator is NAND/NOR logic. Yet, many people prefer to sketch logic diagrams in "English" logic (i. e. AND/OR expressions) and then convert the logic diagram to the NAND/NOR form by writing logic equations and then redrawing the diagram. Many papers and articles have been written describing pencil-and-paper methods to perform this conversion but most of them retain the step involved where complex Boolean equations are written with accompanying chance for typographical errors and with, sometimes, long lists of rules and procedures for converting the equations to "NOR" or "NAND" forms.

BUT, it is not actually necessary to go through all of these procedures to convert english logic expressions directly into NOR or NAND logic diagrams. Only four basic rules need be remembered, two of which are the basic definitions of the NAND or NOR logic circuits. The four rules for construction of a NAND/NOR logic operator diagram are as follows:

Rule 1 — The output of a NAND gate for inputs A and B is $\overline{A \cdot B}$.

Rule 2 — The output of a NOR gate for inputs A and B is $\overline{A+B}$.

Rule 3 — If all inputs to a NAND gate are inverted, the gate performs the English logic OR function on the original inputs. That is, if $\overline{A}$ and $\overline{B}$ are applied to the NAND inputs, the output function is $A + B$.

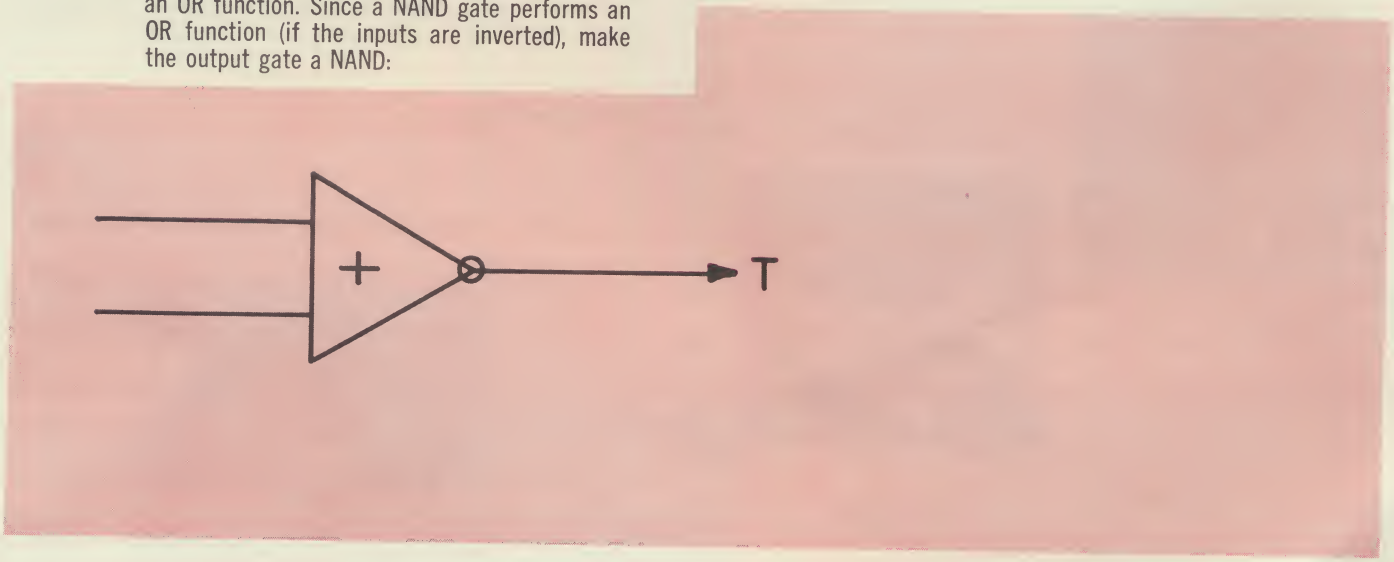
Rule 4 — If all inputs to a NOR gate are inverted, the gate performs the English logic AND function on the original inputs. That is, if $\overline{A}$ and $\overline{B}$ are applied to the NOR gate inputs, the output function is $A \cdot B$.

The following examples are used to illustrate the use of the four very simple rules.

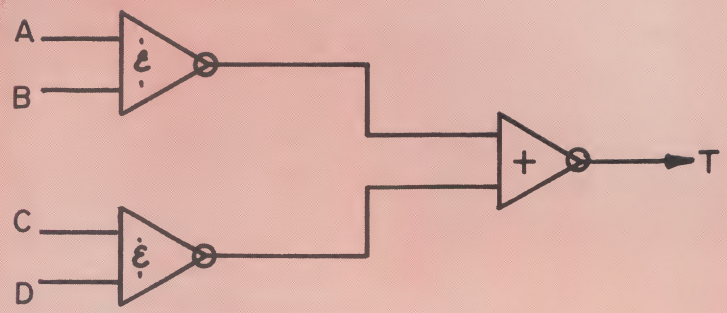
Example 1 — Single Output

Assume the desired function is $T = A \cdot B + C \cdot D$.

Step 1 — The last Boolean algebra function performed is an OR function. Since a NAND gate performs an OR function (if the inputs are inverted), make the output gate a NAND:



Step 2 — The two inputs required on the output NAND gate are the complements of A • B and C • D. These functions are derived directly from Rule 1, and thus the complete logic diagram is as follows:



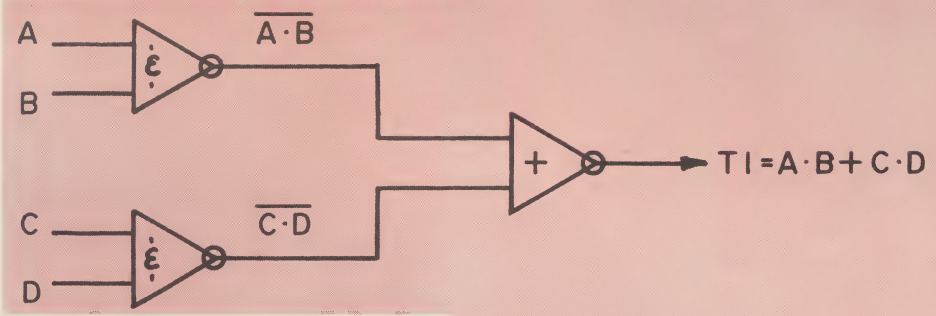
It should be noted that, in the above example, NAND gates are performing both AND and OR functions, and an English logic operator notation has been placed within each logic symbol to indicate which English function the gate is performing. This is very useful on a large and complete system logic diagram for trouble shooting purposes.

Example 2 — Multiple Output

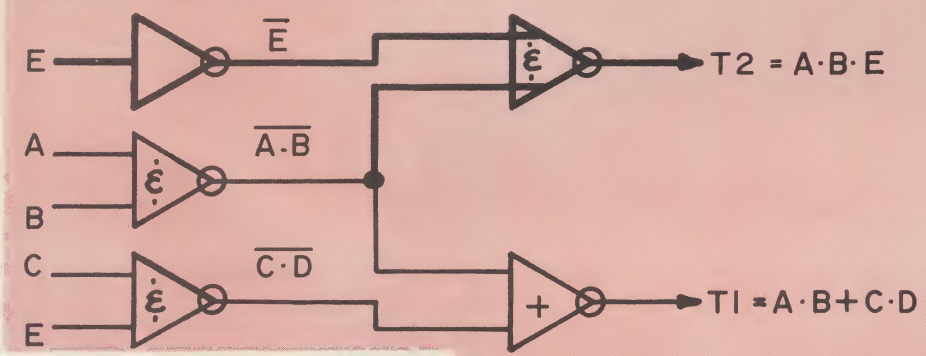
Desired outputs: $T1 = A \cdot B + C \cdot D$

$T2 = A \cdot B \cdot E$

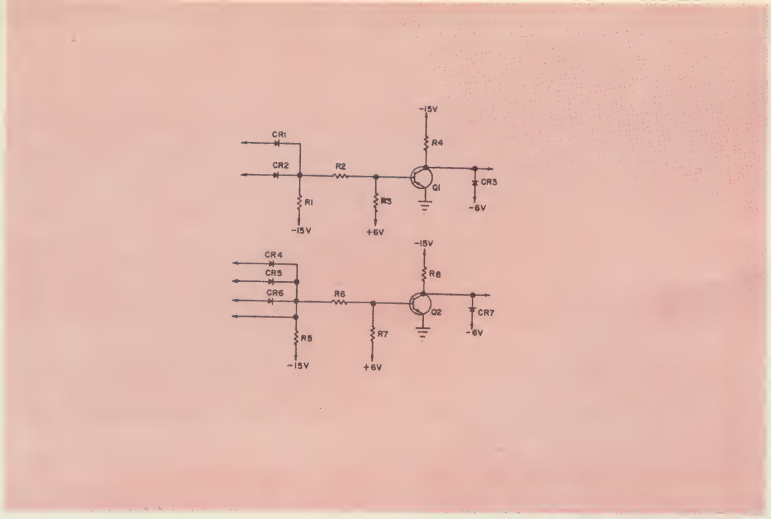
Step 1 — Since T1 is the same output used in example 1, the results are used here.

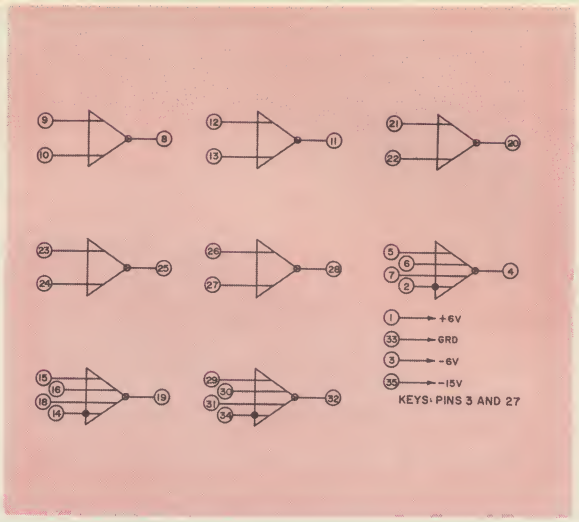


Step 2 — From Rule 4, if all inputs to a NOR are inverted the output will be the English AND of the inputs. Therefore, the $\overline{A \cdot B}$ signal derived above will be used as follows:



As shown, the E input was inverted in order to AND with a NOR, but many times that signal would have been generated in a flip-flop and then the inverter would not have been required.





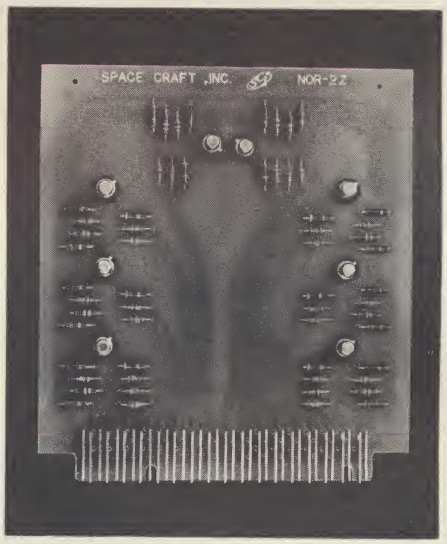
NOR GATES / NOR-2Z

DESCRIPTION

This card contains five 2- input and three 3-input NOR gates using diode-transistor logic. The 3-input NOR gates also have node connections to provide for additional fan-in by means of diode clusters on OR-2Z cards.

These NOR gates may be used in universal fashion to implement logic functions. A diode clamps the output to —6VDC potential when any one of the inputs is supplied with OVDC ("true") voltage level. Only when all of the inputs are at a —6VDC ("false") voltage level does the transistor switch clamp the output to ground potential.

The output logic equation for three inputs A, B, and C is A+B+C. If it is not necessary to use all inputs to a given gate, unused inputs may be left unconnected; i. e. unused inputs do not have to be connected to some "hold off" voltage.



SPECIFICATIONS

Input

Signal Frequency Range: 0 to 1 Mc

Signal Levels: "1" = OVDC (+2V to —0.5V)
"0" = —6VDC (—5.7V to —15V)

Rise and Fall Time: 0.5 microsecond maximum

Input Impedance: 1N load unit

Output

Amplitude: "1" = OVDC (±0.3V)
"0" = —6VDC (—5.7V to —7V)

Rise and Fall Time: 0.2 microsecond maximum, 0.1 microsecond typical

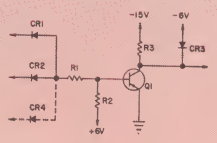
Load Drive Capability: Any load combination up to 3P and 3N load units. (one AC load = 1P + 1N)

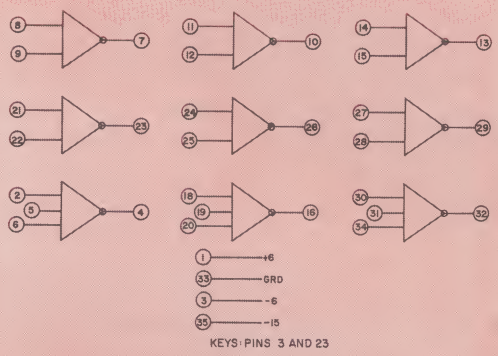
Delay Time: 0.15 microsecond maximum, typical delay in shifting from "0" to "1" is 50 nanoseconds

Power Required

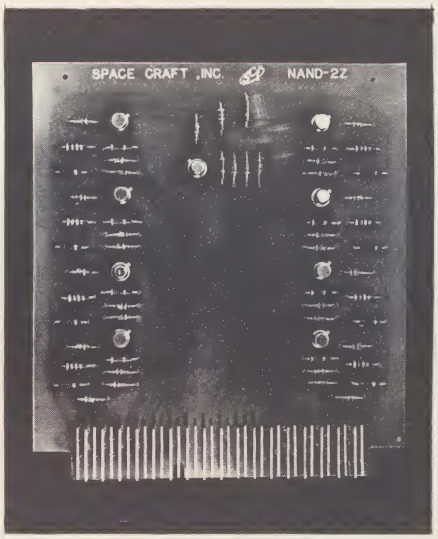
—15VDC (±5%) at 69 ma.
—6VDC (±2%) at 22 ma. (sink)
+6VDC (±5%) at 3.4 ma.

Operating Temperature Range: 0°C to +50°C





NAND GATES / NAND-2Z



DESCRIPTION

This card contains six 2-input and three 3-input NAND gates using diode-transistor logic. Additional fan-in is obtained by connecting outputs of AND-2Z card diode extender circuits to **any** input.

These NAND gates are similar to the NOR gates on the NOR-2Z card except that the input diode gates are oriented to form an AND function rather than an OR function. The output logic equation for three inputs A, B, and C is $\overline{A \cdot B \cdot C}$.

SPECIFICATIONS

Input

Signal Frequency Range: 0 to 1 Mc

Signal Levels: 0VDC (+ 2V to —0.5V) = "1", —6VDC (—5.7V to —15V) = "0"

Rise and Fall Time: 0.5 microsecond maximum

Input Impedance: 1P load unit

Output

Amplitude: "1" = 0VDC (±0.3V)
"0" = —6VDC (—5.7V to —7V)

Rise and Fall Time: 0.2 microsecond maximum, 0.1 microsecond typical

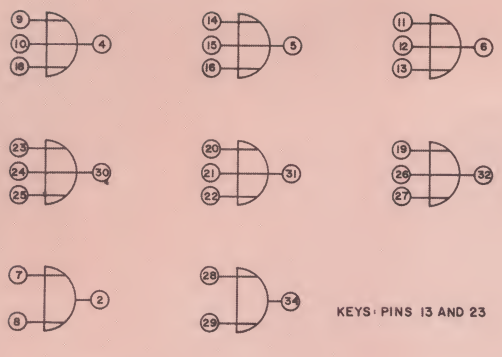
Load Drive Capability: Any load combination up to 3P and 3N load units (one AC load = 1P + 1N)

Delay Time: 0.15 microseconds maximum, typical delay in shifting from "0" to "1" level is 50 nanoseconds

Power Required

—15VDC (±5%) at 53 ma.
—6VDC (±2%) at 37 ma (sink).
+6VDC (±5%) at 1 ma.

Operating Temperature Range: 0°C to +50°C



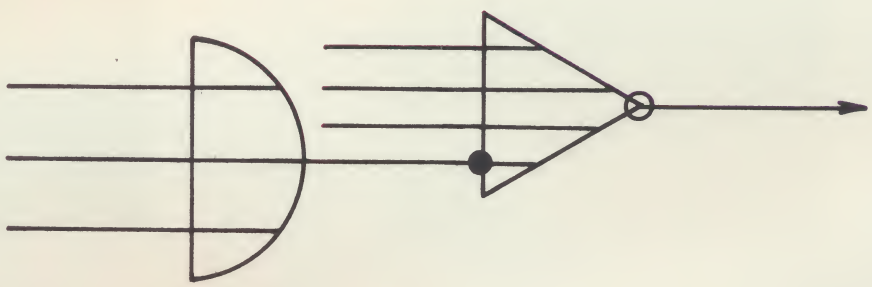
KEYS: PINS 13 AND 23

LOGIC EXTENDERS / OR-2Z & AND-2Z

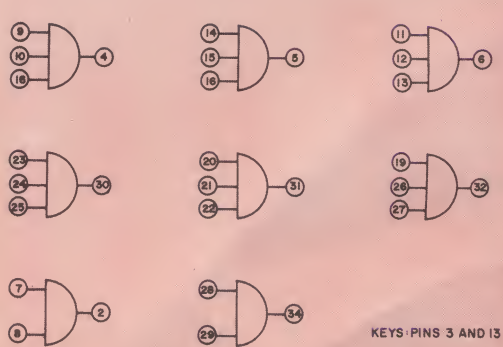
DESCRIPTION

Two types of logic extender cards are offered. These cards consist of diode clusters arranged for OR and AND operations respectively. Each card consists of six 3-diode clusters and two 2-diode clusters.

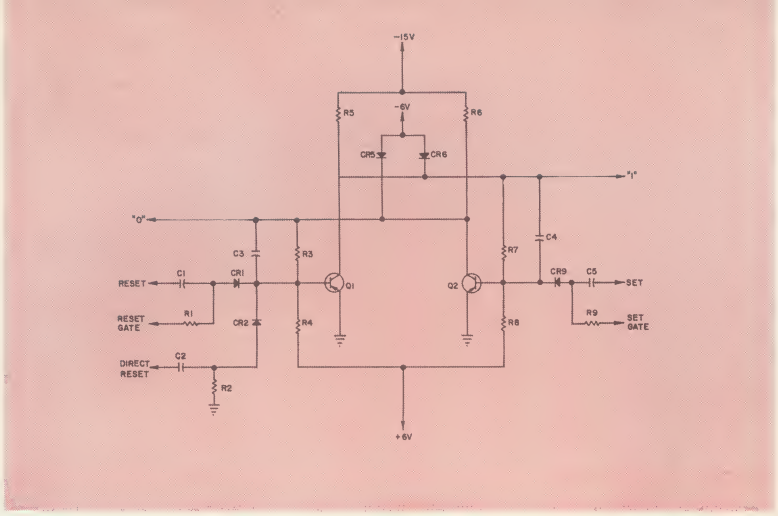
These diode clusters are used to extend the number of inputs on NOR gates (use OR cluster) and NAND gates (use AND cluster). For example, if a 3-input NOR gate is to be expanded to 6-input capability, connections would be made as follows:

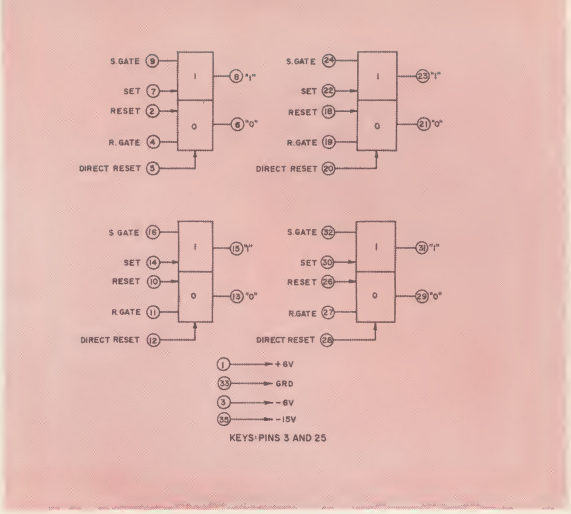


The AND-2Z diode clusters can also be used with a Capacity Driver circuit such as those on the CD-2Z card to provide a NAND gate capable of driving heavy loads. This combination is particularly useful as a reset generator which can accept either automatically-derived or pushbutton-derived signals and provide outputs capable of resetting a large number of flip-flops.



KEYS: PINS 3 AND 13





UNIVERSAL FLIP FLOPS / UFF-2Z

DESCRIPTION

This card contains four general-purpose flip-flop circuits for use as storage or memory devices or for frequency division. The entry points consist of pulse-AND gates. A binary "1" applied at the RESET GATE input enables the pulse-AND gate and a positive-going pulse at the RESET input triggers the flip-flop into a Reset state. Similarly, a binary "1" at the SET GATE input enables a pulse-AND gate and a positive-going pulse at the SET input triggers the flip-flop into a Set state. These circuits may be operated in either of two modes:

(1) In the T (toggle or counter) mode, each input pulse changes the state of the flip-flop. To operate in this mode, connect the "1" output to the RESET GATE input, connect the "0" output to the SET GATE input, and couple input pulses to both the SET and RESET inputs. When so connected, a Set state causes the Reset gate to be enabled and vice versa and, thus, the circuit alternately sets and resets as trigger pulses are applied.

(2) In the RS (reset and set) mode, the circuits respond to alternate set and reset pulses. For example, a positive-going pulse applied at the SET input toggles the flip-flop into a set state (if the SET GATE input is at OVDC-binary "1"). Additional pulses at the SET input have no effect on the flip-flop until a pulse at the RESET or the DIRECT RESET input has triggered the circuit into a reset state.

A DIRECT RESET input is provided on each circuit for cases where several flip-flops are to be synchronously reset. For example, it is usually desirable to reset the flip-flops in a system at power turn on. A single Capacity Driver on a CD-2Z card is capable of resetting up to 20 UFF flip-flop circuits.

SPECIFICATIONS

Inputs

Gate Inputs:

Signal Frequency Range: 0 to 1 Mc

Signal Levels: OVDC (±0.5V) to enable, —6VDC (—5.7V to —15V) to disable

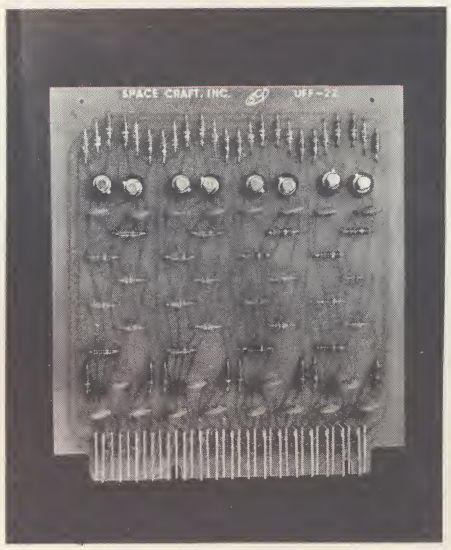
Enable/Disable Time: 0.5 microsecond maximum

Input Impedance: one AC load unit

Pulse Inputs and Direct Reset Input:

Signal Frequency Range: 0 to 1 Mc

Amplitude: 5V peak-to-peak minimum, 7.5V peak-to-peak maximum positive pulse or level shift. Nominal logic levels are "1" = OVDC and "0" = —6VDC



Rise and Fall Time: 0.20 microsecond maximum

Input Impedance: 1 AC load unit at SET, RESET, and DIRECT RESET inputs.

Outputs

Amplitude: "1" = OVDC (±0.3V)
"0" = —6VDC (—5.7V to —7V)

Rise and Fall Time: 0.20 microsecond maximum, 0.1 microsecond typical

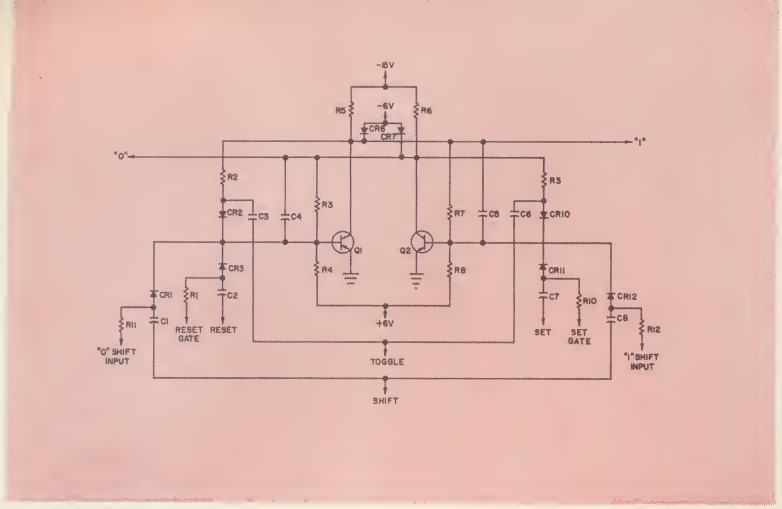
Load Drive Capability: Any load combination up to 3P and 3N load units in addition to 3 AC load units.

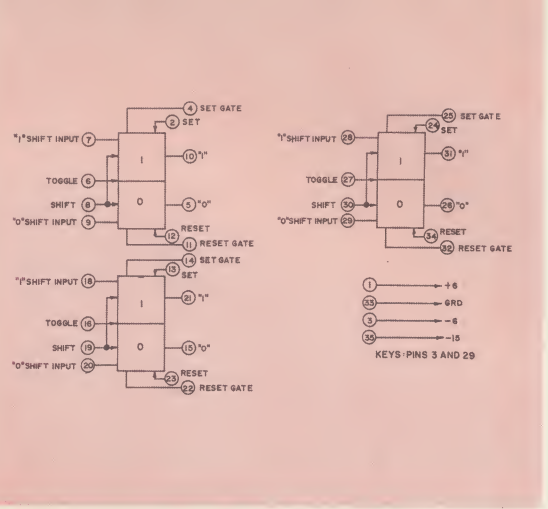
Delay Time: 0.15 microsecond maximum, 0.05 microsecond typical

Power Required

—15VDC (±5%) at 50 ma.
—6VDC (±2%) at 14 ma (sink).
+6VDC (±5%) at 2.1 ma.

Operating Temperature Range: 0°C to +50°C





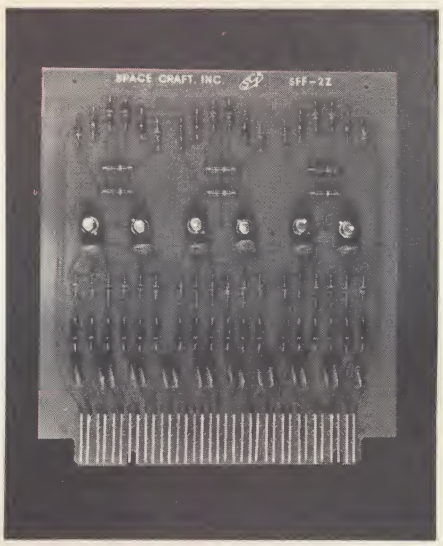
SHIFT FLIP FLOPS / SFF-2Z

DESCRIPTION

There are three shift register flip-flops on this card. Each flip-flop has provision for both serial and parallel entry of data and for serial shift. The entry points consist of pulse-AND gates. A binary "1" level applied at a gate or shift logic input enables the pulse-AND gate and a positive-going pulse at the corresponding pulse input enters the data into the flip-flop.

For serial shift register operation, outputs of the flip-flops are coupled through jumper wires at the connector to corresponding serial-entry control inputs of the next flip-flop in line. Data bits are shifted into the next flip-flop in line when a positive-going shift (or clock) pulse is applied to the SHIFT input. For parallel entry of data, a binary "1" level applied at the SET GATE (or RESET GATE) input enables that gate and the data bit is entered into the flip-flop when a positive-going pulse is applied at the SET (or RESET) input.

A TOGGLE input is also provided such that each input pulse changes the state of the flip-flop. When operated in a toggle mode, the circuits function as binary counters.



SPECIFICATIONS

Inputs

Gate Inputs and "1" and "0" Shift Inputs:

- Signal Frequency Range: 0 to 1 Mc
- Signal Levels: 0VDC (±0.5V) to enable, —6VDC (—5.7V to —15V) to disable
- Enable/Disable Time: 0.5 microsecond maximum
- Input Impedance: One AC load unit

Shift, Set, Reset, and Toggle Inputs:

- Signal Frequency Range: 0 to 1 Mc
- Amplitude: 5V peak-to-peak minimum, 7.5V peak-to-peak maximum positive pulse or level shift. Nominal logic levels are "1" = 0VDC and "0" = —6VDC.
- Rise and Fall Time: 0.20 microsecond maximum
- Input Impedance: Set and Reset Inputs each represent one AC load unit. Shift and Toggle inputs each represent two AC load units.

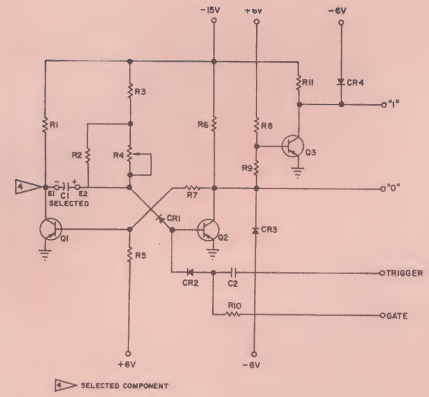
Outputs

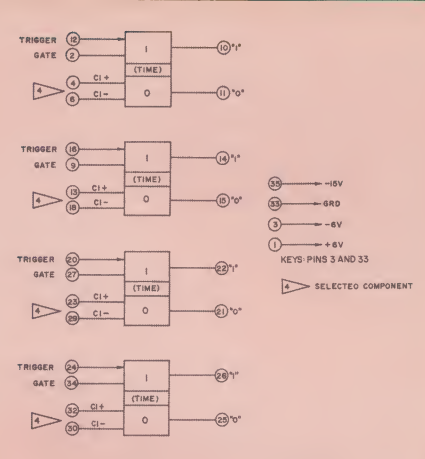
- Amplitude: "1" = 0VDC (±0.3V), "0" = —6VDC (—5.7V to —7V)
- Rise and Fall Time: 0.20 microsecond maximum, 0.10 microsecond typical.
- Load Drive Capability: Any load combination up to 3P and 3N load units, in addition to 3 AC load units.
- Delay Time: 0.15 microsecond maximum, 0.05 microsecond typical.

Power Required:

—15VDC (±5%) at 38 ma.
—6VDC (±2%) at 12 ma (sink).
+6VDC (±5%) at 1.8 ma.

Operating Temperature Range: 0°C to +50°C

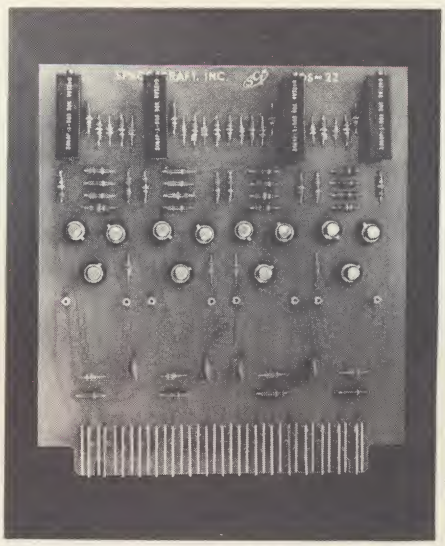




ONE SHOT MULTIVIBRATORS / OS-2Z

DESCRIPTION

This card contains four one-shot (monostable) multivibrators, each capable of providing output pulse widths ranging from one microsecond to 500 milliseconds. The circuits are triggered by positive-going pulses or level shifts on the TRIGGER input if a logic "1" voltage level is applied at the GATE input. The time duration of output pulses is established by adding a timing capacitor at a place provided on the board. Further, trimpots are provided for each circuit to facilitate fine adjustment of output pulse width. A curve that defines the approximate relationship between timing capacitance and output pulse duration is shown below.



SPECIFICATIONS

Inputs

Trigger Input:

- Signal Frequency Range: 0 to 1 Mc
- Amplitude: 5V peak-to-peak minimum, 7.5V peak-to-peak maximum positive pulse or level shift. Nominal logic levels are "1" = 0VDC and "0" = —6VDC
- Rise and Fall Time: 0.20 microsecond maximum
- Input Impedance: one AC load unit

Gate Input:

- Signal Frequency Range: 0 to 1 Mc
- Signal Levels: 0VDC (±0.5V) to enable, —6VDC (—5.7V to —15V) to disable
- Enable/Disable Time: 0.5 microsecond maximum
- Input Impedance: one AC load unit

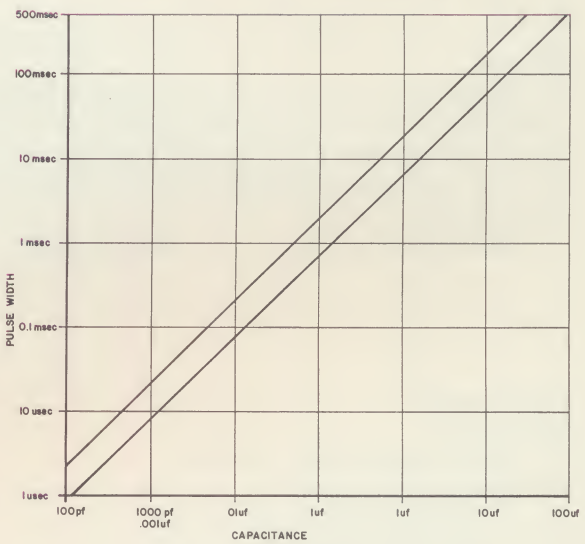
Outputs

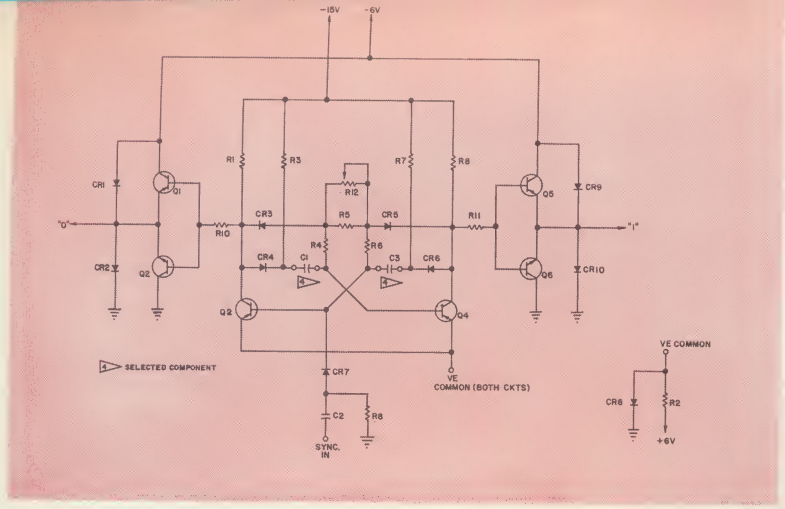
- Amplitude: "1" = 0VDC (±0.3V), "0" = —6VDC (—5.7V to —7V)
- Rise and Fall Time: 0.20 microsecond maximum, 0.10 microsecond typical
- Pulse Width: Adjustable from 1 microsecond to 500 milliseconds through selection of timing capacitor and adjustment of trimpot
- Maximum Duty Cycle: 70%
- Load Drive Capability: Any load combinations up to 2P and 2N load units (one AC load = 1P + 1N)

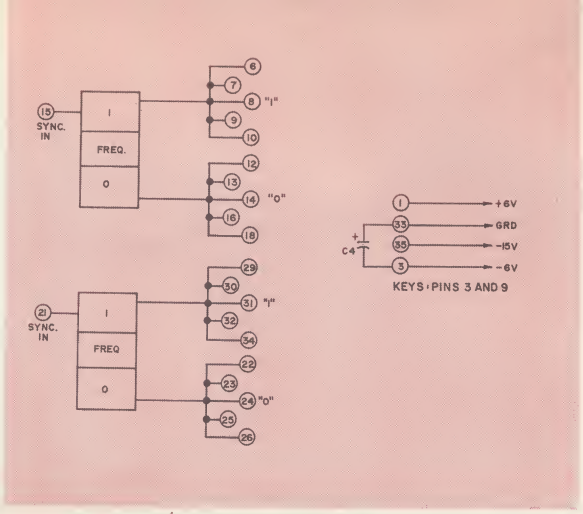
Power Required

—15VDC (±5%) at 50 ma.
—6VDC (±2%) at 17 ma (sink).
+6VDC (±5%) at 0.8 ma.

Operating Temperature Range: 0°C to 50°C







MULTIVIBRATORS / MV-2Z

DESCRIPTION

Two general-purpose multivibrator circuits that can be used to generate square waves and time base frequencies are available on this card. The operating frequency of each multivibrator is established by two timing capacitors. The approximate relationship between capacitance of the timing capacitors and operating frequency is illustrated in the curve below. A bandwidth is shown because trimpots are provided for each circuit to facilitate fine adjustment of the output frequency.

Each of the multivibrators can operate in either a free-running or a synchronized mode. Additionally, to provide frequency multiplication, each multivibrator can be synchronized by an input frequency somewhat lower than the frequency of oscillation. Frequency multiplication by factors of 2, 3, 4, or 5 is possible at output rates as high as 1 mc. This is done by using the input pulse rate to synchronize the multivibrator at a frequency slightly higher than the second, third, fourth or fifth sub-harmonic of the free-running frequency of the multivibrator. If, for example, it is desired to multiply an input 100 kc pulse rate to a 500 kc pulse rate, timing capacitors would be selected such that the circuit would free-run at approximately 490 kc. Input 100 kc pulses then force the multivibrator to operate at 500 kc by re-synchronizing it on every fifth cycle.

The following chart defines the nominal harmonic relationship of the synchronizing (locking) signal to the MV output. Figures shown in the right-hand column are the percentage deviations from the free-running frequency over which reliable locking can be obtained.

SYNC/FREE-RUN FREQ.	LOCKING RANGE
F	0 to +45%
F/2	0 to +40%
F/3	0 to +15%
F/4	0 to +10%
F/5	0 to +10%

SPECIFICATIONS

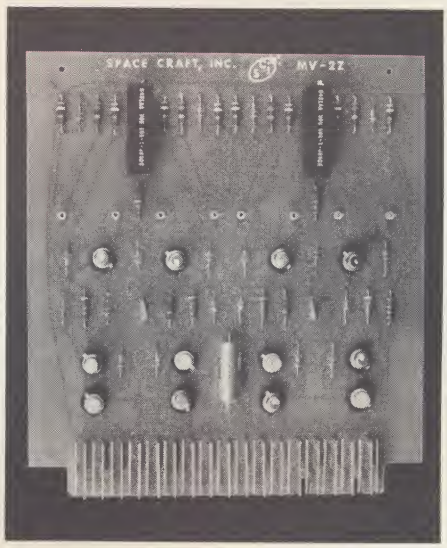
Input (if used)

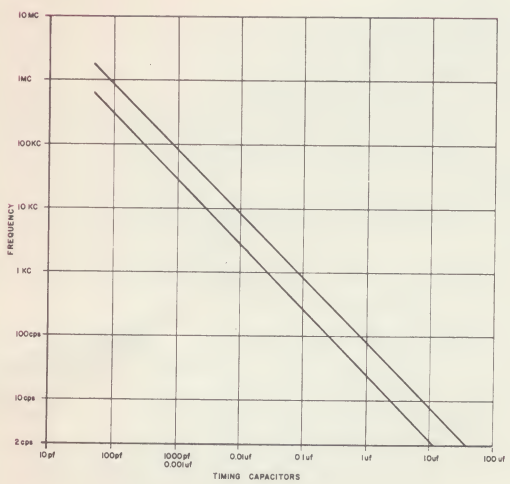
Signal Frequency Range: 0 to 1 Mc

Amplitude: 5V peak-to-peak minimum, 7.5V peak-to-peak maximum input positive pulses or level shifts. Nominal logic levels are "1" = 0VDC and "0" = —6VDC

Rise and Fall Time: 0.20 microsecond maximum

Input Impedance: one AC load unit





Output

Amplitude: "1" = 0VDC (±0.5V), "0" = —6VDC (—5.7V to —7V)

Rise and Fall Time: 0.20 microsecond maximum, 0.1 microsecond typical

Load Drive Capability: Any load combination up to 35P and 20N load units (one AC load = 1P + 1N)

Frequency Stability in Free-Running Mode: 10% over the operating temperature range. 2% over a temperature range that is limited to 20°C ±10°C.

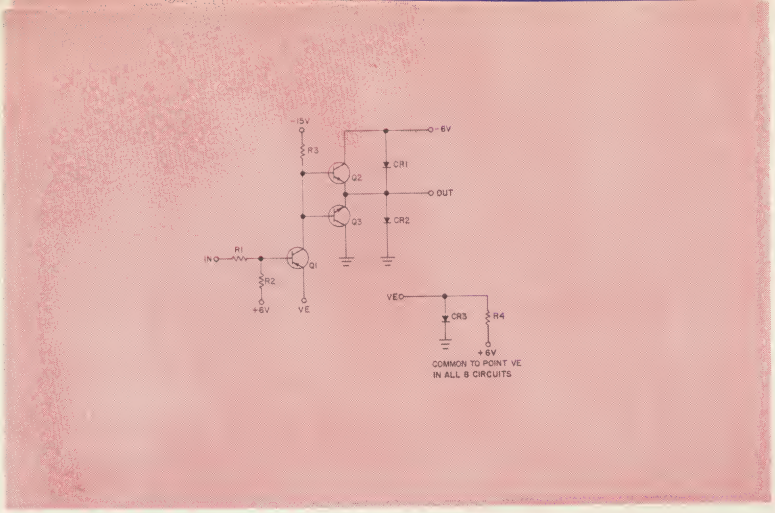
Note: Temperature characteristics of timing capacitors affect overall frequency stability.

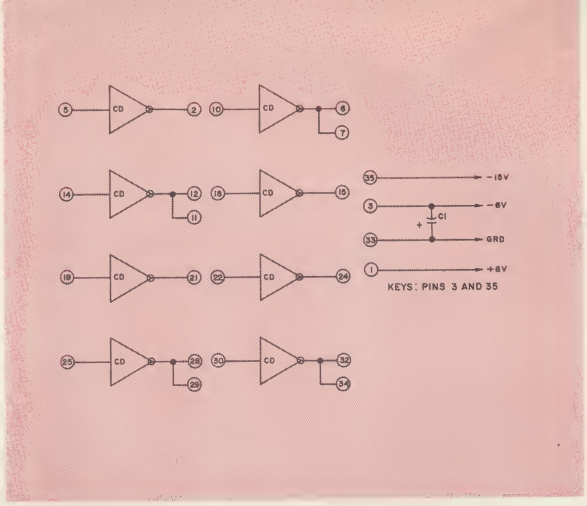
Frequency Range: Adjustable from 2 cps to 1 Mc through selection of timing capacitors and adjustment of trimpot.

Power Required

—15VDC (±5%) at 27 ma.
—6VDC (±2%) at 0 to 90 ma. (depending on load)
+6VDC (±5%) at 34 ma.

Operating Temperature Range: 0°C to +50°C



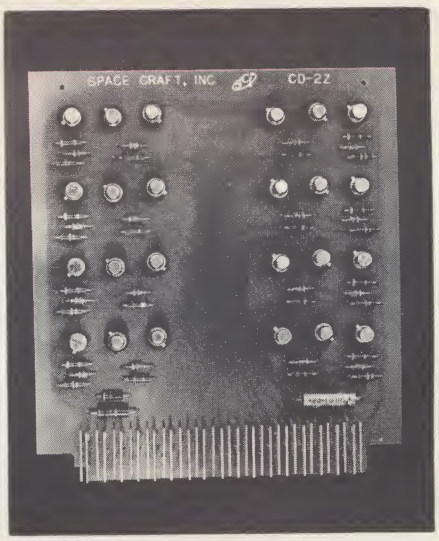


CAPACITY DRIVERS / CD-2Z

DESCRIPTION

Eight amplifier circuits with complementary-symmetry emitter follower outputs are available on this card. The emitter follower circuits are completed through the input impedance of the driven circuit. These Capacity Driver circuits feature low output impedance and are used to drive heavy loads.

The AND-2Z diode clusters can also be used with a Capacity Driver circuit such as those on the CD-2Z card to provide a NAND gate capable of driving heavy loads. This combination is particularly useful as a reset generator which can accept either automatically-derived or pushbutton-derived signals and provide outputs capable of resetting a large number of flip-flops.



SPECIFICATIONS

Input

Signal Frequency Range: 0 to 1 Mc

Signal Levels: "1" = 0VDC (+6V to —0.5V), "0" = 6VDC (—5.7V to —15V)

Rise and Fall Time: 0.5 microsecond maximum

Input Impedance: 1P load unit

Output

Amplitude: "1" = 0VDC (±0.5V)
"0" = —6VDC (—5.7V to —7V)

Rise and Fall Time: 0.20 microsecond maximum, 0.1 microsecond typical

Delay Time: 0.15 microsecond maximum

Load Drive Capability: Any load combination up to 35P and 20N load units, (one AC load = 1P + 1N)

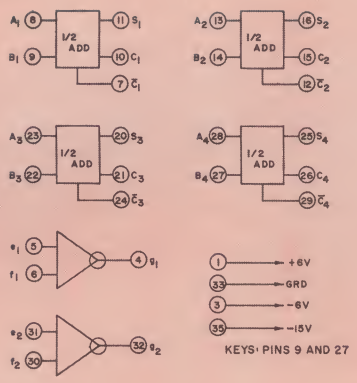
Power Required

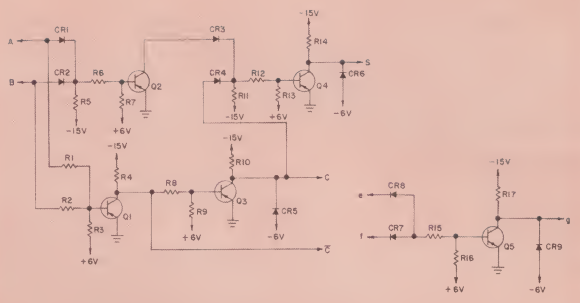
—15VDC (±5%) at 25 ma

—6VDC (±2%) at 0 to 370 ma maximum (current depends on load)

+6VDC (±5%) at 50 ma

Operating Temperature Range: 0°C to +50°C





ADDER CARD / ADD-2Z

DESCRIPTION

The Adder Card contains four half-adder circuits and two 2-input NAND circuits. These circuits can be combined to form two full-adders, each requiring two half-adders and a NAND circuit.

The logic equations that define outputs of a **half-adder** are:

Sum = $S = A\bar{B} + \bar{A}B$

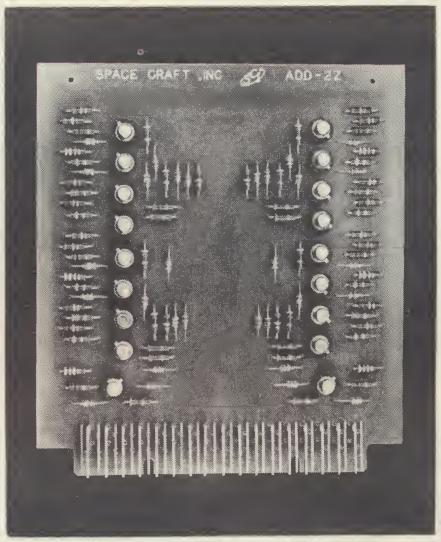
Carry = $C = AB$

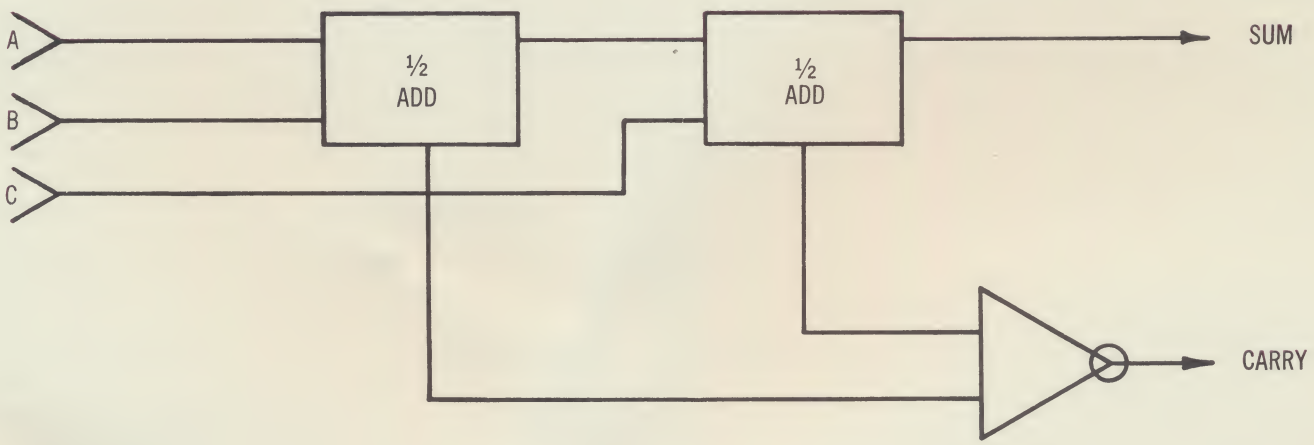
Two half-adders and a NAND circuit are required for a full-adder because a full-adder is formed when a third input, a carry from the next lowest significant digit, is added to the sum. The logic equations that define outputs of a **full-adder** are:

Sum = $A\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}\bar{B}C + ABC$

Carry = $AB\bar{C} + A\bar{B}C + \bar{A}BC + ABC$

The manner in which the two half-adders and the NAND circuit are connected to form a full-adder is as shown below. Note that the "not-carry" outputs of the half-adders are applied to the NAND circuit.





SPECIFICATIONS

Input

Signal Frequency Range: 0 to 1 Mc

Signal Levels:

"1" = 0VDC (±0.5V)

"0" = −6VDC (−5.7V to −7V)

Rise and Fall Time: 0.5 microsecond maximum

Input Impedance: NAND inputs, 1P load unit, Half-Adder inputs, 1P and $\overline{1N}$ load unit.

Outputs (Sum, Carry, $\overline{\text{Carry}}$, NAND)

Amplitude:

"1" = 0VDC (±0.3V)

"0" = −6VDC (−5.7 to−7V)

Rise and Fall Time: 0.2 microsecond maximum

Load Drive Capability: Any load combination up to 3P and $\overline{3N}$ load units (one AC load=1P+1N)

$\overline{\text{Carry}}$ Load Drive Capability: 1P load unit

Delay Time: Typical delay through a half-adder is 0.15 microsecond and 0.3 microsecond through a full-adder.

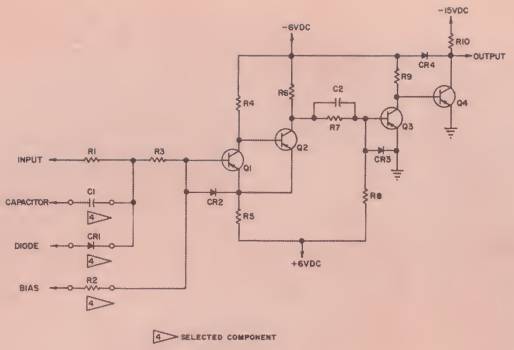
Power Required

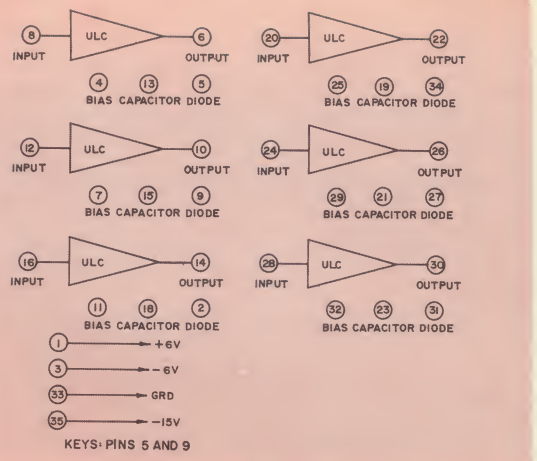
−15VDC (±5%) at 110 ma

−6VDC (±2%) at 42 ma (sink)

+6VDC (±5%) at 5.5 ma

Operating Temperature Range: 0°C to +50°C





UNIVERSAL LEVEL CONVERTERS / ULC-2Z

DESCRIPTION

This card contains six Schmitt Trigger circuits, each followed by a buffer amplifier. When the signal voltage applied at the input of these circuits goes more positive than the upper trigger point (UTP), the output switches rapidly to logic "1". The output will remain in this state until the input goes more negative than the lower trigger point, at which time the output switches rapidly to the logic "0" state. Output transition times are less than 0.20 microsecond regardless of input transition time.

These circuits are typically used for such purposes as waveform restoration, squaring of sinusoidal or non-rectangular inputs. DC level detecting, or signal level shifting. The trigger level on each circuit is adjustable by applying a suitable bias voltage and selecting a bias resistor. This bias voltage adjusts the threshold level of the amplifier to adapt it for use with input signals which have minimum amplitudes equal to or greater than 3 volts peak-to-peak. The relationships between bias voltage and upper and lower trigger points for several values of bias resistance are defined by the curves below.

On each of the Schmitt Trigger circuits, terminals are provided for selecting values of bias resistor, input clamp diode, and integrating or coupling capacitor. The following paragraphs contain examples of uses for these circuits that illustrate their high degree of flexibility.

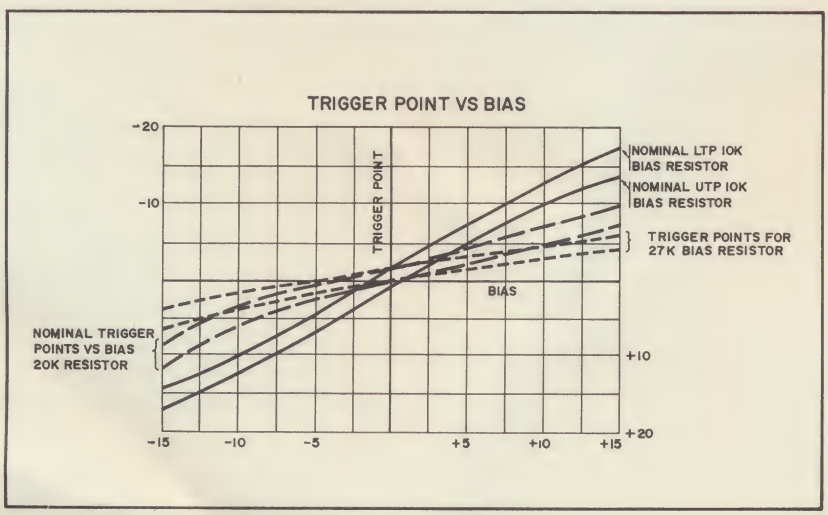
To use the circuit to integrate an input signal, such as for elimination of relay contact bounce, make the following connections:

a. Connect the input signal to the DC input.
b. Put proper integrating capacitor in the staked terminals provided on the board.
c. Connect the AC input to ground (or some voltage).
d. Put desired bias resistor in the staked terminals provided on the board.
e. Connect the BIAS input to the proper bias voltage.

If the 1-kilohm resistor in series with the DC input is not large enough for the particular application, then a suitable resistor may be selected and placed in the staked terminals normally used for the input clamp diode. The input signal would then be connected to the DIODE input, thus providing a larger resistor for integrating purposes.

To use the circuit to convert the AC portion of a sinusoidal wave to an output square wave, make the following connections:

a. Place a suitable coupling capacitor in the staked terminals provided and connect the input signal to the AC input.
b. Select the bias resistor and connect the BIAS input to desired voltage.



If desired an input voltage divider network may be established by returning the 1-kilohm resistor at the DC input to some voltage and by selecting a resistor for the diode terminals and returning the DIODE input to some voltage.

To use the circuit for conversion of other logic levels to the 0V and—6V levels used by the -2Z Series cards, make the following connections:

a. Connect the input signal to the DC input.
b. Put the proper bias resistor in the staked terminals provided on the board.
c. Return the BIAS input to the proper bias voltage.

SPECIFICATIONS

Input

Signal Frequency Range: 0 to 1 Mc

Level Shift to Change Output: 3V peak-to-peak minimum, 50V peak-to-peak maximum

Input Impedance: 10 kilohms. (see description)

Output

Amplitude: 6V nominal, "1"= 0VDC (±0.3V)
"0"=—6VDC (—5.7V to —7V)

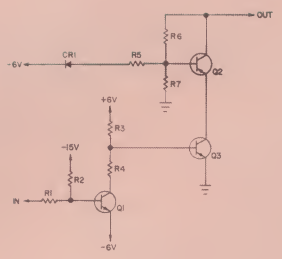
Rise and Fall Time: 0.2 microsecond maximum, 0.1 microsecond typical

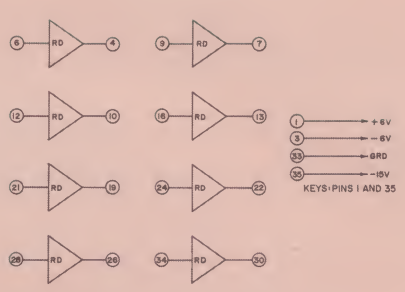
Load Drive Capability: Any combination up to 3P and 3N load units. (one AC load=1P+1N)

Power Required

—15 VDC (±5%) at 90 ma.
—6VDC (±2%) at 60 ma (sink).
+6VDC (+5%) at 20 ma.

Operating Temperature Range: 0°C to +50°C





RELAY DRIVERS / RD-2Z

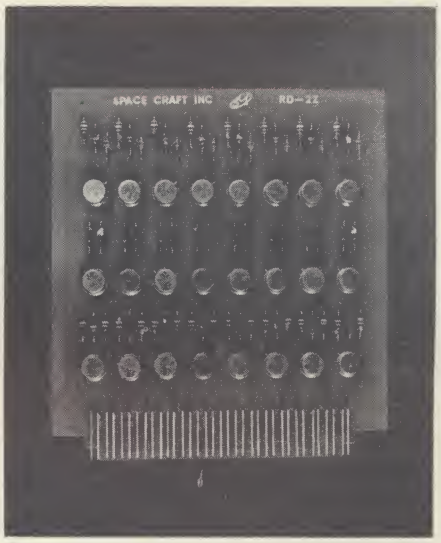
DESCRIPTION

This card contains eight separate driver amplifier circuits that are basically transistor switches which may be operated directly from the outputs of any active circuits. Input signal levels required are OVDC and —6VDC and each circuit is capable of supplying up to 120 milliamperes at terminal voltages up to —52V.

The most common application for these circuits is control of general-purpose relays. In this mode, reverse-surge clamp diodes are required across the relay coil to protect the output transistor.

A second use for these circuits is to drive incandescent indicators. Most satisfactory operation is achieved if a GE #327 bulb is used and a 2.7-kilohm resistor is connected between the driver output and ground. This resistor serves a dual purpose. It allows a small amount of "keep-alive" current to flow, thus extending the life of the bulb. Second, due to this "keep-alive" current, it minimizes surge currents when the bulb is turned on thus protecting the driver's output transistor.

A third use for these drivers is as output signal level shifters. A resistive divider network can be established at the output of these circuits to develop logic levels with as much as 50 volts spread.



SPECIFICATIONS

Input

Signal Frequency Range: 0 to 50 kc (max. frequency with relay load depends on relay capabilities)

DC Signal to Activate: OVDC (+6V to —0.5V)

DC Signal to Deactivate: —6 VDC (—5.7V to —15V)

Rise and Fall Times Required: 50 microseconds maximum

Input Impedance: 1N load unit

Output

Maximum Output Current: 120 ma.

Maximum Output Supply Voltage: —52V

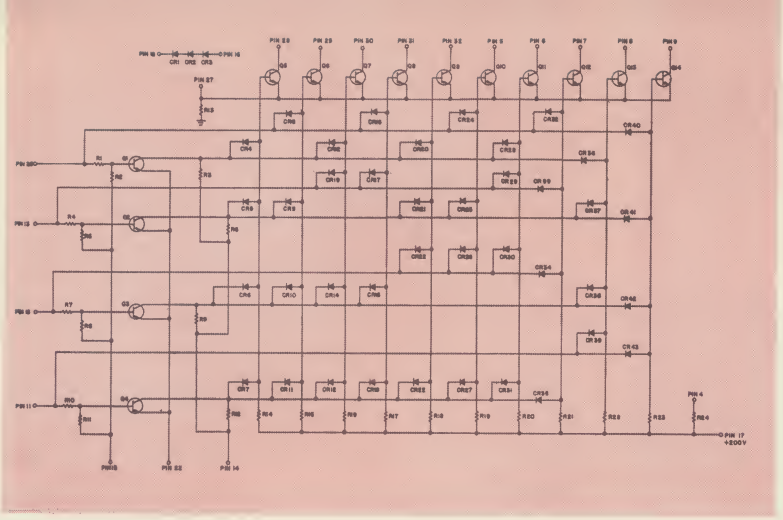
Rise Time: 2 microseconds maximum

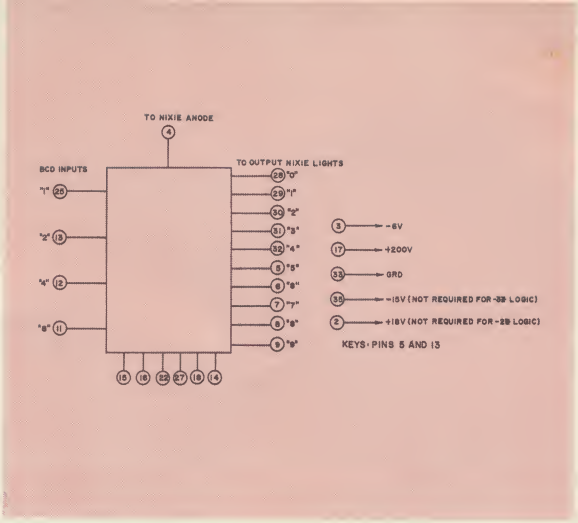
Current Leakage through Load (in "off" condition and at worst-case temperature): 100 microamperes maximum

Power Required

—15 VDC (±5%) at 2 ma.
— 6 VDC (±2%) at 100 ma.
+ 6 VDC (+5%) at 3.5 ma.

Operating Temperature Range: 0°C to +50°C





NIXIE DRIVER / ND-2Z

DESCRIPTION

The Nixie Driver card contains a diode decoding network and driver circuits required to control a nixie tube. Four inverter circuits are on the card and, thus, only the four "true" signal inputs of 1-2-4-8 coded BCD data are required.

Further, the board is arranged such that the board can be driven by either 0VDC and —6VDC logic levels or by 0VDC and +8VDC logic levels simply by changing jumper wires on the printed circuit connector. These jumper wire connections are as follows:

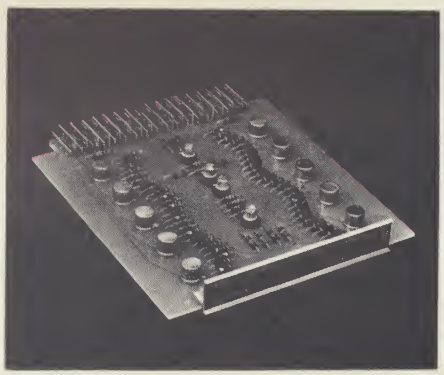
—6VDC AND 0VDC INPUT LEVELS

Jumper: Pin 15 to Pin 35
Pin 18 to Pin 22 to Pin 3
Pin 14 to Pin 33
Pin 16 to Pin 27

+8VDC AND 0VDC INPUT LEVELS

Jumper: Pin 15 to Pin 3
Pin 22 to Pin 33
Pin 16 to Pin 14 to Pin 2
Pin 18 to Pin 27

Silicon semiconductors are used throughout. This card, therefore, is electrically and physically compatible with both the -2 Series (germanium) family and the -3 Series (silicon) family.



SPECIFICATIONS

Input:

Signal Frequency Range: 0 to 250 Kc

Signal Levels:

If jumpers connected for 0V and —6V inputs:
"1" = +1VDC to —1VDC, "0" = —5VDC to —10VDC

If jumpers connected for 0V and +8V inputs:
"1" = +5VDC to +10VDC, "0" = —1VDC to +1VDC

Input Impedance: 20K returned to —6V for 0V and —6V inputs (⅛N and ½P load unit)
20K returned to Ground for 0V and +8V inputs

Output:

Load Drive Capability: Designed to drive a Burroughs type B5991 Nixie tube

Power Required:

—15VDC (±5%) at 0.3 ma.
— 6VDC (±5%) at 8 ma.
+175 to 200VDC: 5 ma at 175VDC (recommended voltage)

Operating Temperature Range: 0°C to +100°C

WARRANTY

Space Craft, Inc. warrants standard circuit cards and modules of our manufacture to be free from defects for a period of five years from delivery. If a standard circuit card or module fails in normal service within that period due to defective parts, workmanship, or packaging and the purchaser notifies the company immediately, Space Craft will replace the card or module without charge upon return of the defective item.

This warranty does not extend to any cards or modules which have been subjected to misuse, neglect, accident, or improper installation or application. Nor does it extend to products which have been repaired or altered outside of our factory.

For service under this warranty, advise the factory immediately of all pertinent details. Transportation charges covering return of defective products to our factory shall be at our expense if such products are determined to be defective within the limitations of this warranty. Space Craft, Inc. will repair or replace the defective card or module according to its own best judgment. Space Craft, Inc. requests immediate notification for any claims arising from damage in transit in order to determine if carrier responsibility exists.

Should such returned material prove to be defective outside the limitations of this warranty by reason of elapsed time, or due to damage caused by misuse, accident, neglect, or improper installation, it will be repaired, if repair is feasible, at cost.

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OTHER CARDS

Several other cards have been developed, tested, and used in systems. These cards are built to order and complete technical information is available upon request. The following paragraphs contain brief descriptions of these special cards.

DIGITAL-TO-ANALOG CONVERTER DAC - 2Z

This card contains a 10-bit, non-storing digital-to-analog converter. It accepts parallel inputs at rates up to 250KC and provides an output accuracy of 0.1%. Output amplitude per bit is adjustable over the range of 5 millivolts to 10 millivolts per bit. The output is short-circuit-proof to ground.

BINARY-TO-BCD CONVERTER DECADE B/BCD - 2Z

This card is used with associated control circuitry to perform conversion of binary number to 1-2-4-8 coded BCD form. The card contains four shift register flip-flops (and associated conversion circuitry) and is used as a decade in a shift register. The number of decades required for a given conversion, of course, depends on the largest binary number to be converted. Input gates and shift gates are configured such that data may be circulated in the register at clock rates up to 1 MC.

FLIP-FLOP REGISTER FFR - 2Z

Ten flip-flop modules are on this card which can be used as an input or output data register. All flip-flops have common DIRECT SET, SET, and DIRECT RESET inputs. Application of a positive-going pulse to the DIRECT SET input will set all flip-flops to a "1" state. Similarly, a pulse to the DIRECT RESET input will reset all flip-flops to the "0" state. Each flip-flop has an isolated SET GATE input which, when enabled with a binary "1" level, will allow the flip-flop to be set to a "1" state when a positive-going pulse is applied at the SET input. The register operates at shift rates up to 1 MC.

RELAY BOARD RY - 2Z

Twelve Grigsby - Barton Inc. type GD-21A-R-1000 SPST reed relays are on this card. They can be driven by RD-2Z relay drivers or other switching devices to isolate signals between digital systems, drive incandescent lamps, and many other applications.

SPECIAL LEVEL CONVERTERS ZLC - 1Z and ZLC - 2Z

Each of these cards contains twelve level conversion circuits operable at frequencies up to 500KC. Circuits on card ZLC - 1Z convert input -3V and -11V levels to outputs of -6V and 0V respectively. Circuits on card ZLC-2Z convert input 0V and -6V levels to outputs of +8V and 0V respectively.

PRICE LIST

-2Z SERIES
STANDARD LOGIC CARDS

Effective 1 April 1965

PART NO.	QUANTITY				
	1-9	10-25	26-100	101-200	201-500
NAND-2Z	47.30	45.92	44.46	43.52	42.57
NOR-2Z	45.40	44.08	42.68	41.77	40.86
AND-2Z	24.14	23.44	22.69	22.21	21.73
OR-2Z	24.14	23.44	22.69	22.21	21.73
UFF-2Z	47.93	46.53	45.05	44.10	43.14
SFF-2Z	47.74	46.34	44.87	43.91	42.96
OS-2Z	55.25	53.64	51.93	50.83	49.72
MV-2Z	83.84	81.40	78.81	77.13	75.46
CD-2Z	70.03	67.99	65.83	64.43	63.05
ADD-2Z	65.83	63.91	61.88	60.56	59.25
ULC-2Z	58.14	56.45	54.65	53.49	52.33
RD-2Z	54.10	52.52	50.85	49.77	48.69
ND-2Z	60.88	59.11	57.23	56.00	54.80

Quantity 500 and up, consult factory.

Terms and Conditions

Terms are net 30 days. Prices are f.o.b. Huntsville, Alabama. Prices and specifications are subject to change without notice. S.C.I. assumes no obligation to incorporate production changes into previously delivered equipment.

PRICE LIST

-2 SERIES
STANDARD LOGIC CARDS
Built to MSFC-PROC-158B on Lead Tin
Boards that Meet MSFC-STD-154

Effective 1 May 1965

PART NO.	QUANTITY		
	1-24	25-99	100-199
NAND-2	63.91	61.99	60.08
NOR-2	63.42	61.52	59.61
AND-2	33.63	32.63	31.61
OR-2	33.63	32.63	31.61
UFF-2	71.42	69.28	67.13
SFF-2	62.22	60.35	58.49
OS-2	80.14	77.74	75.33
MV-2	91.40	88.66	85.92
CD-2	78.67	76.31	73.95
ADD-2	87.14	84.53	82.31
ULC-2	80.18	77.77	75.37
RD-2	85.20	82.64	80.09
ND-2	79.19	76.81	74.44

Quantity 200 and up, consult factory

Terms and Conditions

Terms are net 30 days. Prices are f.o.b. Huntsville, Alabama. Prices and Specifications are subject to change without notice. SCI assumes no obligation to incorporate production changes into previously delivered equipment.

PRICE LIST

-2 SERIES
WELDED MODULES

Effective 1 May 1965

PART NO.	QUANTITY				
	1-9	10-25	26-100	101-200	201-500
NAND-2M	20.26	19.65	19.04	18.64	18.23
NOR-2M	27.00	26.19	25.39	24.84	24.30
AND-2M	16.02	15.54	15.06	14.74	14.42
OR-2M	16.02	15.54	15.06	14.74	14.42
UFF-2M	26.60	28.80	25.00	24.47	23.94
SFF-2M	32.00	31.04	30.08	29.44	28.80
OS-2M	21.65	21.00	20.35	19.92	19.49
MV-2M	32.98	31.99	31.00	30.34	29.68
CD-2M	30.18	29.27	28,37	27.77	27.16
ADD-2M	23.05	22.36	21.67	21.21	20.74
ULC-2M	20.29	19.68	19.07	18.67	18.26
RD-2M	23.54	22.83	22.13	21.66	21.19

Quantity 500 and up, consult factory.

Terms and Conditions

Terms are net 30 days. Prices are f. o. b. Huntsville, Alabama.

Prices and specifications are subject to change without notice.

S. C. I. assumes no obligation to incorporate production changes into previously delivered equipment.

PRICE LIST

-2 SERIES
PLUG-IN WELDED MODULES

Effective 1 May 1965

PART NO.	QUANTITY				
	1-9	10-25	26-100	101-200	201-500
NAND-2MP	25.28	24.52	23.76	23.26	22.75
NOR-2MP	33.53	32.52	31.52	30.85	30.18
AND-2MP	21.04	20.41	19.78	19.36	18.94
OR-2MP	21.04	20.41	19.78	19.36	18.94
UFF-2MP	28.60	27.74	26.88	26.31	25.74
SFF-2MP	39.70	38.51	37.32	36.52	35.73
OS-2MP	27.28	26.46	25.64	25.10	24.55
MV-2MP	39.82	38.63	37.40	36.63	35.84
CD-2MP	32.77	31.79	30.80	30.15	29.49
ADD-2MP	28.67	27.83	26.95	26.37	25.80
ULC-2MP	26.60	25.80	25.00	24.47	23.94
RD-2MP	29.27	28.39	27.51	26.93	26.34

Quantity 500 and up, consult factory.

Terms and Conditions

Terms are net 30 days. Prices are f. o. b. Huntsville, Alabama.

Prices and specifications are subject to change without notice.

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